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Performance Analysis of Energy Efficiency for Wireless Sensor Networks in Healthcare Applications

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Abstract

Wireless Sensor Networks (WSNs) are designed to careaccessible real-time monitoring of the environment, which depends on the region involved. The main experiments in WSN include energy optimization, routing, identification of obstacles, security, etc. Energy efficiency is theimportant issue for all types of WSNs. The sensor systems are focused by a battery and therefore turn out to be gone after a specific interval. Improving data indulgence in an energy-efficient way is more important to upgrade the lifetime of maximum sensor devices in the overall network. The clustering technique has already been shown to improve or enhance the life span of WSNs. In the existing clustering model, the Cluster Head (CH) collection in each one is considered to be a skilled method for energy-efficient method of routing, which minimises the broadcast delay in the network. The Low Energy Adaptive Clustering Hierarchy (LEACH) protocol is analysed in this paper to minimise energy consumption. An analytical method for evaluating energy consumption built on a graph is presented. Analysis and simulation results indicate that the k-Means algorithm which can save an enormous amount of energy compared to the LEACH protocol with the similar amount of data rate, bit error rate, and other parameters for a specific area of network. It is related with the k-Means algorithm to obtain the performance of different datasets in healthcare applications.

1. INTRODUCTION

WSN has different applications on various platforms. Sensor devices are usually battery-powered devices. They are inexpensive and compact, and serve to collect useful data and send it over wireless lines from areas of the body to subsidence nodes. The battery cannot be replaced in the real-time network operation. The sensor communication takes place internally or directly with in the networks. Several methods are used to extend the life of the network, such as selecting the right number of components, protocol methods to improve energy efficiency, and collection of parameters to ensure the efficient operation of the network.Energy is one of the substantial aspects in the WSNs. Life through the grid depends on the best use of energy resources. Therefore, optimization is very important to use energy efficiently. There are two main classes of WSN path tags: structural guides and hands-on approaches. In a latency protocol, all nodes are used at such a rate and are considered. In addition, the previous packet management reduced capacity further and, as the network size increased, so did power usage.

There are two types of routing protocols, e.g. network construction and protocol operation. Routing models have been installed for increased healthiness, increased scalability and compact data re-transmission. In order to improve the system lifespan, hierarchical routing protocols are used which contribute to network scalability, data collection and minimise delays in data transmission of network communications. It is described in numerous works that routing models, in particular clustering systems, are creating significant developments for WSNs. Hierarchical routing is used to minimise network act and energy use while the entire network sensor node sends data to the base stations. The overall grouping of energy utilisation models in WSNs with concentrated energy protection hubs has

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already been proposed. Moreover, energy improvement in WSN is a different methodology relying on the floor plan actualized and the reason for the procedure.

WSNsarea groupwhich involves an enormous amount of nodes which are intensely settled in the actual climate for observing temperature, stickiness, vibration, items, shading, etc. Sensor nodes convey gathered data to the sink. Correspondence between the sink and the administrator nodes is shared through Internet or satellite. WSNs are having more number of applications which incorporate medical care, conservation, public security, military frameworks, industry, etc. WSNs are generally used for natural observing, target following, front line reconnaissance, mechanical indicative, savvy space, and security the executives applications, however its plan is quite possibly the most difficult in the field of remote correspondence as sensor nodes impart a long distances, scattering a lot of restricted energy asset while directing information to the sink. Apart from sending and receiving energy per bit, sensor's versatility additionally brings about high energy utilization and expanded organization traffic, prompting high transfer speed interest. Coordinating energy-productive grouping calculations into WSN plans in this manner turns into a consoling option in contrast to guaranteeing maintaining and convenient conveyance of information for most of the applications.

1.1 Applications of WSNs in Healthcare Systems

WSNs play a very important role in healthcare applications, eco-friendly applications, public protection, military systems, and industry and transport systems. WSNs are extensively utilised for environmental monitoring, goal tracking, battlefield surveillance, commercial diagnostic, clever space, and safety management applications.Its layout is one of themaximumhardwithinside thearea of wireless communication as sensor nodes share a far distances, scattering a massivequantity of restrainedstrengthservicethough routing facts to the sink.Apart from transmitting and receiving powerin line with bit, sensor’s mobility additionally incurs excessivepowerintake and expandedcommunity traffic, main to excessive bandwidth demand. Incorporating power-green clustering tactics into WSN designs consequently develops a comforting replacement to making sure for maintaining and well-timedtransport of records for maximum applications. The smartincorporated sensor used inside the healthcare tracking with maximum facilities.It is used to monitor the patients, organization of drugs inhospitals which in turn decreases the chances of recommending theincorrect medication to the patient.In-house process andmovement of insects and animal are observed by sensors.WSN has a lot of exclusiveexperiments and limitations such as self-management, energyrestriction, congested packet broadcasts, ad-hocdeployment, unattended operation, etc. This uniquestructure nature of WSN strains a procedure designedthat should fit for its fields, especially for the customer for healthcare services.

2. RELATED WORKS

Various combinations of algorithms are applied in WSNs in different manner by designing many protocols for the problems furnishedwithspecific objectives. WSNs deployed in a forest, it's milesprofitable to forecastfewstages of mobility. Thus, evaluation of the movement of nodes at theoverall performanceof those protocols and assessmentare monitored. The changes of nodes at each minute are considered when those protocols can tolerate the evaluation of the performance of a few proposed techniques during designing of cellularWSNs. Although an excellentwide variety of protocols and algorithms had been deployed for conventionalwireless ad-hoc networks, they may benow no longernicelyideal to the specificcapabilitiesand alertnessnecessities of sensor networks [1]. Sensor networks considerablyfluctuate from conventional networks which includemobile networks

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and cellularadvert hoc networks (MANETs), wherein routing and mobility control are done to optimise the QoS and bandwidth performance, without recourse to power consumption.

Emerging developments in group communications and QoSleaningpackages over WSNs have extended the need for scalable and bettercommunity support. In thosecorrespondences, verbal exchange and coordination amongst a given set of nodes are essential for routing protocols and for presenting WSNs with vocal exchange efficiency. Most routing protocols require regionfacts to manual sensor nodes, and this fact is crucial to permit the computation of paired nodes distance and clean estimation of the fed onstrength. Optimising this distance turns into a hard and calls for nature-stimulated solutions. Recent studies works have used nature-stimulated methods [2-4] for strength optimisation of WSN.

In [5][6] the researchers designed a hybrid algorithm as K-Means PSO to obtain energy optimization for the WSNs. In that work resolution of energy drain within the network found the best scattering of sensors and CHs increase the network period and minimizing the energy utilization. Here the authors planned the concept on providing a hybrid cluster formula primarily based K-Means cluster and Particle Swarm optimisation (PSO) to attain an economical energy management of the network. The designed formula is compared with the regular cluster techniques like the LEACH protocol and K-means cluster one by one.

3. ANALYSISOF ENERGY OPTIMIZATION TECHNIQUES

A complete study has been accompanied to the different protocols with the energy consumption, and reduction in wastage of consuming the power in networks. Moreover, several strategies are bestowed to cut communications at the network layer, that area unit cited as routing protocols. Many technical experiments conducted on different routing protocols and their results are analysed in the WSNs and, the most effective and also classified area by divided into 3 categories as,

i. Planning the duty cycle
ii. Planning the data orientation
iii. Plans based on mobility

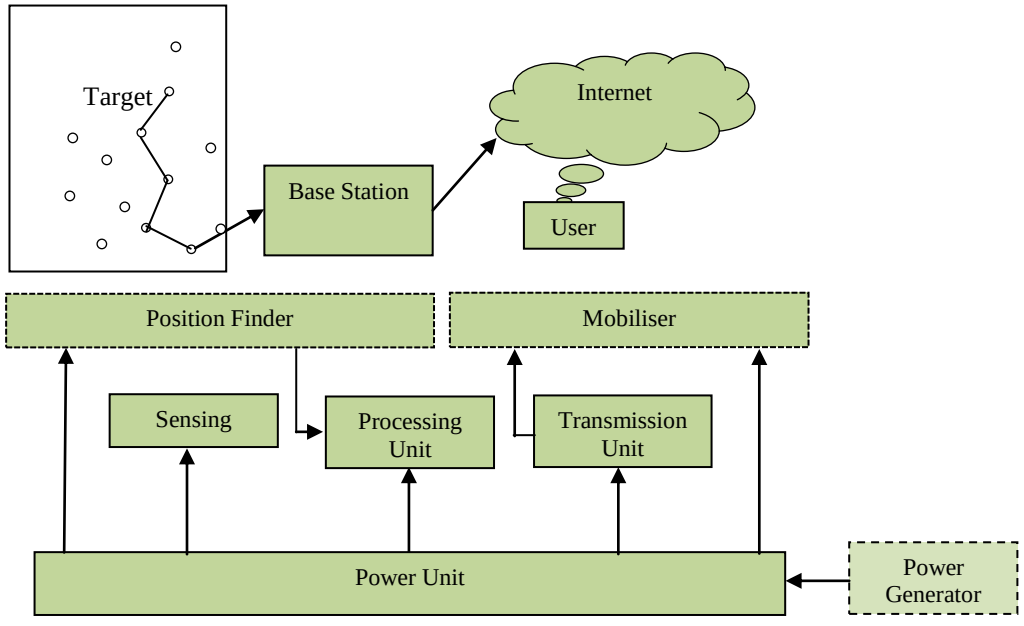

Figure 1. Major components of a sensor node in WSN

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The major parts of device nodes square measure shown in figure one. In one of these ways, sensors path is measuredrandomly within the surroundings and also the level of energy consumption of each nodeare calculated. Similarly, the sink node takesthe time expected for observing travelling distance and consuming energy inside the network.Additionally the time required for direct communication between sensors and receiving the particular measurementsare also needed for saving the power consumption. In wireless device, nodes are driven by battery having with restricted energy. Replacement and recharging of the battery aren't doable since nodes could also be started within the hostile or impractical surroundings. Thus it is required to choose the supply of energyfor battery driven nodes.

3.1 Clustering for WSN

Clustering has been broadlydone for research withvarious techniques and applied for networks in so many applications[7][8]. It's capable of improving the network life that is a necessary feature for calculating the quality of a sensing element network. Enhancing the static network life of the Ad-hoc networks was proposed in latest applications. Within the network, the lifetime of node isintegrated until all the primary nodestravelledhappened because of battery discharge. Clusteringalso happened in WSN contains grouping nodes into a team and selecting a specific CH. The CH is liable for assembling knowledge from sensing element nodes in its cluster and communicating the important information for taking decision.

Although an authentic variety of protocols and algorithms are deployed for ancient wireless Ad-hoc networks, they are not compatible to the distinctive options and application needs of sensing element networks. Moreover, sensing element networks contains an oversized variety of nodes that square measure designed for breakage in its operation. Their topology additionally changes terribly of times and in contrast to typical networks, they specialize in prolonging the network's period and preventing degradation in property, through economical energy management[9][10]. The rejection makes energy conservation a key concern within the style of mobile WSNs, and to save energy, a group of criteria that allows information gathering at every cluster head (CH) to avoid redundant assignments of knowledge to the base station is important.

3.2 LEACH Protocol

LEACH protocol is a famous routing technique which is widely used in WSNs. It selects the CH supported chance distribution perform. LEACH protocol appears in two different types of sections like setup section and steady-state section. The CH election is finished sporadically and in an exceedingly randomised manner throughout the setup section. The steady-state section is split into consecutive number of frames. Every frame of data to be transmitted in equally distributed slots and activated continuously for every alive node[11][12]. Throughout every frame, every sensor node sends the required information to its CH, and so the head sends the gathered information to the base station. Then the technique has control to minimize the energy consumption of the detector nodes. However, it doesn't guarantee sensible distribution or uniform illustration of the cluster heads. In-spite of its non-uniformity in CH illustration, LEACH is taken into account a testing the benchmark for many WSNs by thecombination of algorithms.

The LEACH protocol is one in all the foremost standard class-conscious routing algorithms for device networks [13][14]. Basically, LEACH could be a dynamic cluster methodology. During this methodology, time is divided into fastened intervals with equal length that is termed topology update interval or spherical here. At the start of every interval, every device becomes a CH because of control

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taken by a chance. The CH then broadcast required details to their neighbours when the center gives the command. Allsensors receive messages and become a member of a cluster by selecting the closest cluster. During the interval, cluster members directthe information to their cluster head. The cluster heads combine, compress, and route the data towards the remote access purpose. At the end of each node, the total topology construction procedure starts the communication. Hence, the clusters and CH do not urge to send messages. Since the CHs consume more amount of energy than other members in radio transmission and aggregation, the rotation of cluster heads makes additional energy consumption for equally across all sensors among the network.The node becomes a CH for the present topology within the allotted interval if the number 'n' is less than the following threshold:

$$T(n) = \frac{p}{1-p*(i \bmod -\frac{1}{p})}, if\ n \in G \quad (1)$$

where p is that the desired part of cluster heads, 'i' is that the range of this topology update interval, and G is that the set of nodes that haven't been cluster heads within the last 1/p intervals. Within the 1sttopology update interval, i = zero and T(n) for all the nodes is 'p'. Therefore, the sensing element network will last longer. Optimum range of cluster heads is calculable to be 5% of the entire range of nodes. All processing, like information merging and aggregation, square measure natural to the cluster andcluster heads amendment is created by the node selecting a random range between zero and one.

3.3 K-Means Clustering

K-means clustering algorithmic rule may be a classic and usually used cluster algorithmic rule. The rule is especially divided into 2 elements. The primary half conducts density-based cluster on small part of information within the entire information set. Within the second half, supported the cluster results of the primary half, the remaining information area unit is divided into corresponding clusters in step with the concept of progressive cluster[6]. Its main operation is to search out the mean of the weather in every cluster set and set it with the cluster center. The primaryconcept of the algorithmic rule is to divide the part set into totally different clusters once recurrent iterations, and apply the criterion perform of the analysis cluster classification.

K-means cluster algorithmic rule may be a classic and ordinarily used cluster algorithmic regulation. K-means cluster algorithmic rule is especially divided into 2 components. The primary half conducts density-based clustering on the initial part of information within the entire dataset. In the second half, the supported cluster results of the primary half, the remaining information results to measure the divided part corresponding clusters per the concept of progressive cluster. Its main operation is to search out the mean of the weather in every cluster set and set it because the cluster center. The most used technique of the algorithmic rules are to divide the part of data set into completely different clusters when recurrent iterations happened, and apply the criterion operatesin the analysis cluster classification.

$$J = \sum_{j=1}^{k} \sum_{i=1}^{n} ||\text{Sij} - \text{CHj}||2 \quad (2)$$

where ||Sij - CHj|| is a taken distance quantityamong a sensor 'S' number 'i'makes to the cluster 'j' and the CH for 'n' sensors.The flow chart of k-means algorithm is as follows:

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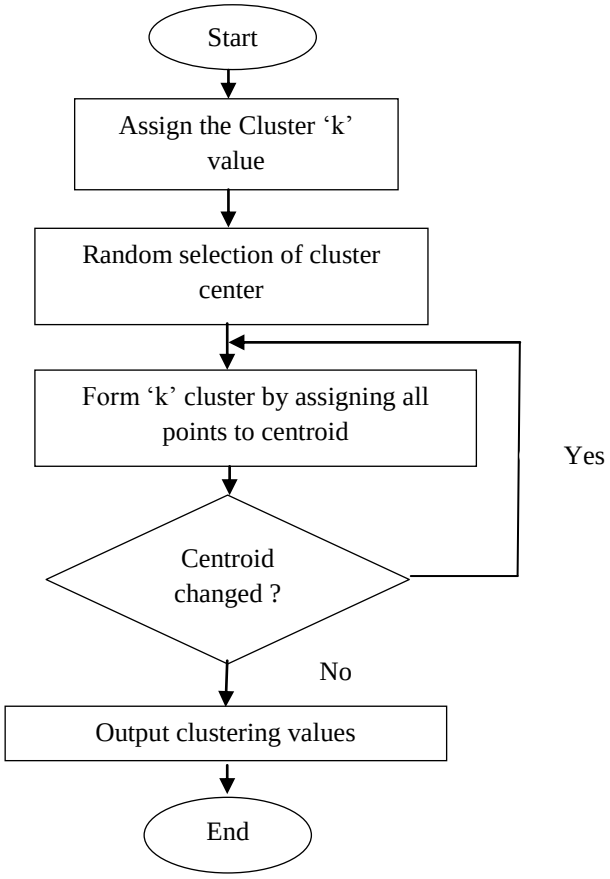

Figure 2: Flow graphof K-means algorithm.

The main drawback of the K-Means algorithm is to find the K value of the clustering number which should beselected before assigning the center. So this algorithm can be applied, after the selection of this K rate is veryhard forapproximation. The frequent changes of the clustering number K is the disadvantages of K-Means clustering algorithm. Due to this the K-Means algorithm will take more time for the Healthcare applications when the routing needs fast changes in certain cases. However, despite its quality, the formula has sure limitations, together with issues related to random data format of the centroids that results in surprising convergence.

4. **SIMULATION RESULTS**

The multi-objective genetic algorithm was used to achieve the minimisation operation, which was carried out at a central base station and the results forwarded to the network nodes. A MATLAB simulation was implemented on the LEACH protocol and K-Means algorithm models then compared the effectiveness of the proposed algorithm.Some of the graphical user interface of the results implemented from the above algorithms area shown in figures.

These are the steps to calculate the parametersof by LEACH protocol to know the pros. and cons.

Step 1: Initialize the energy of a node
Step 2: Cluster heads selection process
Step 3: Grouping all the nodes into different clusters
Step 4: Calculating the distance between each node and the cluster head
Step 5: Energy dissipation for all the normal nodes
Step 6: Energy dissipation for the cluster head nodes

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Some of the data values of WSN are listed from the result from the simulation for analysing the various parameters related to the nodes taken for the application. The sample data of nodes like base station position, and number of sensor nodes and location, simulation parameters are simulated by MATLAB workspace, or manually entered at the time of simulation.

It is important to extend the network life time by working the network with continuing energy and therefore the total changehappened with the sensors throughout the simulation are considered. Theother energy based algorithms are studied during this analysis. During a transmission cycle, every node sends one information message to its CH. Then the CH gathers the expected information into one frame of data. Finally, the CH directs the shared message to the base station.

4.1Simulation results of LEACH protocol

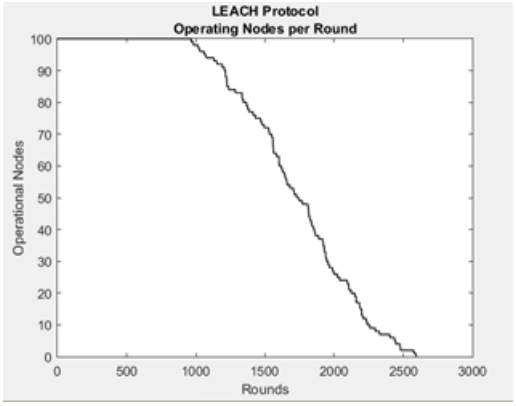

Figure3 : Operating Nodes per Round

Additional to this the comparison between various parameters of k-means algorithms in terms completely various parameters on different categories of dataset, required comparison of those algorithms were analysed from the graph.For the LEACH protocol[7] the operating nodes for each round is shown in the Figure 3**.**which gives the meaning of each round the nodes position and variations.

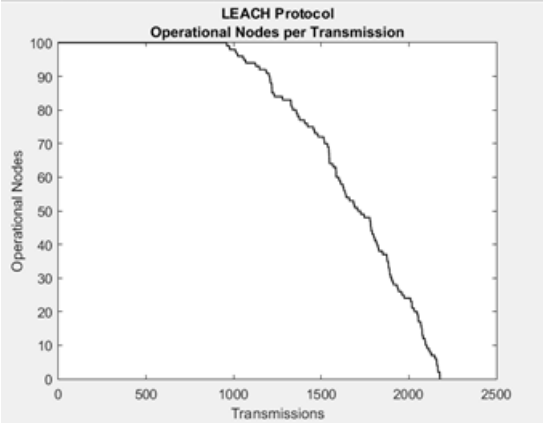

Figure 4: Operational Nodes per Transmission

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In Figure 4. the graph drawn for the different values of the operating nodes in the network with the transmission. For the 100 nodes the operations performed in the network by the algorithm was shown and analysed.

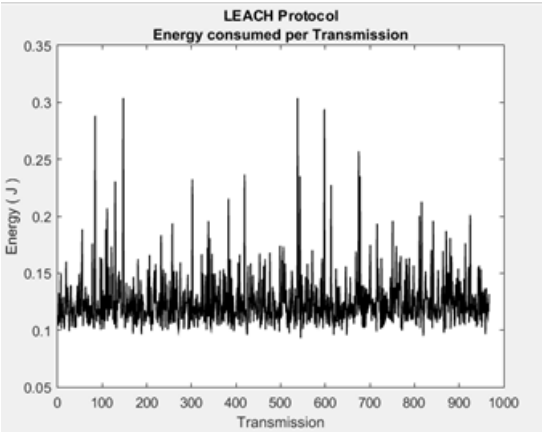

Figure 5: Energy consumed per Transmission

The Figure 5: shows the energy taken by each node istaken average with respect to the various transmissions happened in the network considered. It will be further analysed through the parameters obtained from other techniques.Both the time and space complexities [8][15][16] of those algorithms rely on the dimensions 'n' of the datasets. Finding associate best answer for the k-means algorithmic rule is difficult within the Euclidean space for each the binary and multi-class collection issues. The subsequent Table 1: shows the comparison of each algorithm with numerous parameters and compared with the required application.

Table 1: Parameters observed from the Simulation of LEACH and k-Means algorithms

Sl. No	Parameters	LEACH Values	Parameters	K-Means Values
1	Number of Nodes	100	Number of Nodes	100
2	Network size ($K \times K$)	100 m × 100 m	Network size ($K \times K$)	100 m × 100 m
3	Sink node position	(50,200)	K-means Iteration	40
4	Size of the data package	4000	Size of the data package	4000
5	Suggested percentage of cluster head	5%	Suggested percentage of cluster head	8%
6	Number of Clusters	5	Number of Clusters	8
7	Energy	0.0044 Jules	Energy	0.0031 Jules
8	Number of rounds	2429	Number of rounds	1854
9	EDA	7 nJ / bit message	EDA	5 nJ / bit message
10	Data Aggregation Energy	$5x10^{-9}$Jules	Data Aggregation Energy	$3.5x\ 10^{-9}$ Jules

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4.2 The Outcome of Mobility of Nodes in the Network

Movement of nodes can make interruption of cluster nodes from their heads that may causes data damage. Thus, as the speedof nodes isenlarged, the rate of performance of topology updateprocess should be improved. Regarding the performance oftopology update process is an energy overridingtask[9], accuratechange of topology assignment break is of high significanceto increase the period of the network forming.From the above table the various parameters are identified to understand the need of node positions, the center of the each cluster, cluster heads etc. The total power consuming in the WSNs for the various applications in different fields are identified with above values. Due to the above analysis taken in the specified area of network with the 100 nodes, it can be taken as a result for any type of recent IoTapplications [11][13][14]. Under this category the healthcare monitoring is one of the important domains to handle more number of patients to monitor their health parameters for identifying patients data, regular data from body, sending the values on any critical condition to the hospital and doctors etc. should be controlled with fast and secured manner. So the latest algorithms with proper routing between the nodes as well as consuming less energy are analysed in this paper.

5. CONCLUSIONS

The experimental studyrevealedthat there is no commonresult for the problems of the LEACH and k-meansalgorithms for WSNs rather each of the existingdeviations of the algorithm is either application-specific or data-specific.The K-means algorithm handles the network and dividesthe WSN into afixed number of clusters.The energy consumed in both algorithms calculated with same number of nodes with different number of clusters. The performance of these algorithms carried out for the various sectors in healthcare applications are decided and depends upon the position of nodes in network, life time of the nodes, cluster head selection etc. Finally the k-means algorithm is somewhat better than the LEACH routing technique. Thus the objectives of the paper are studied about the drawbacks happened in the WSNs when the algorithms are used for solve various criteria. The healthcare is one of the important sectorsfor sharing and providing the solution for emergency situations. So the routing about nodes in between the network with secured [10] and easy way of communication is the need from the latest techniques for better service.

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